



High-Volume Manufacturing of EUV Mask Blanks *Status and Roadmap*

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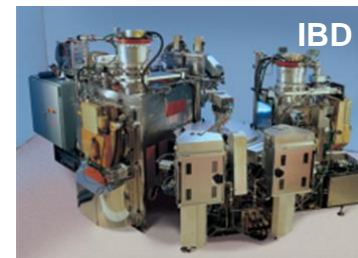
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Veeco Ion Beam Technology Background

- ❖ Ion beam is a 'core' technology for Veeco
- ❖ Over 30 years experience in advanced etch and deposition
- ❖ Veeco developed & built several successful product lines based on ion beam technology
- ❖ Veeco has adapted ion beam technology and developed the IBD-LDD for EUV mask blanks
 - ❖ Development began with LLNL in late 90s
 - ❖ Collaboration with Sematech and major mask companies in the 2000s
- ❖ The Veeco IBD-LDD is the tool-of-record for Mo/Si multilayer deposition
 - ❖ Committed to ongoing IBD-LDD development
 - ❖ Actively validating roadmap to support EUV market

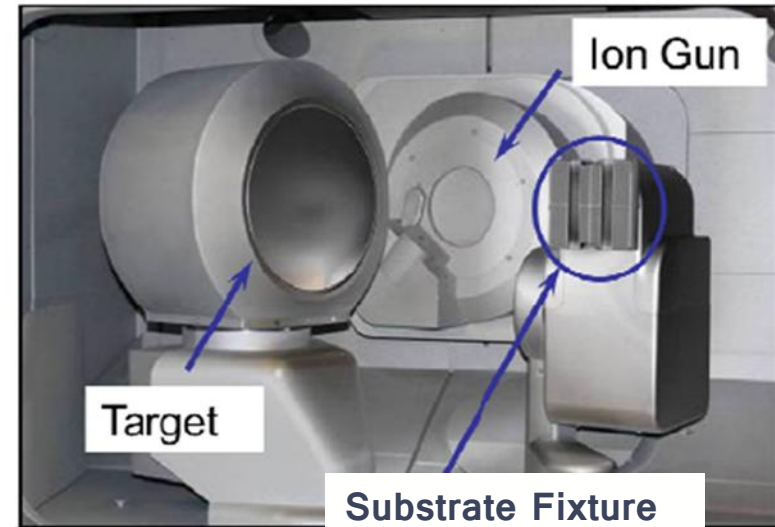
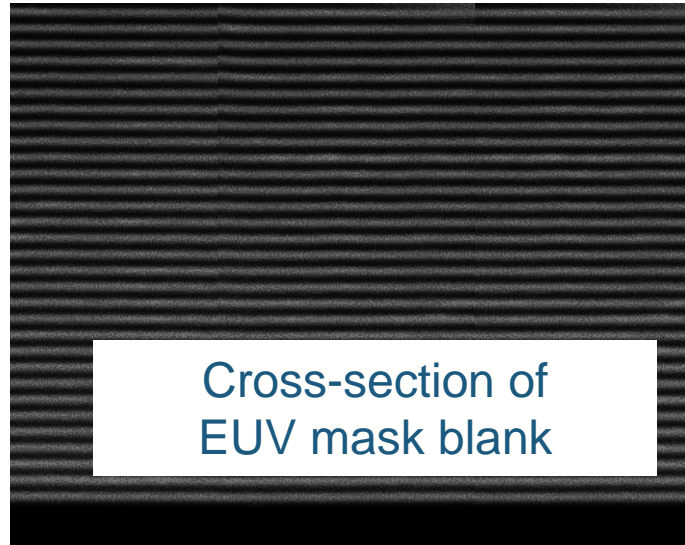


Ion Beam Deposition for Low Defect Deposition

cap layer
(2.5 nm Ru)

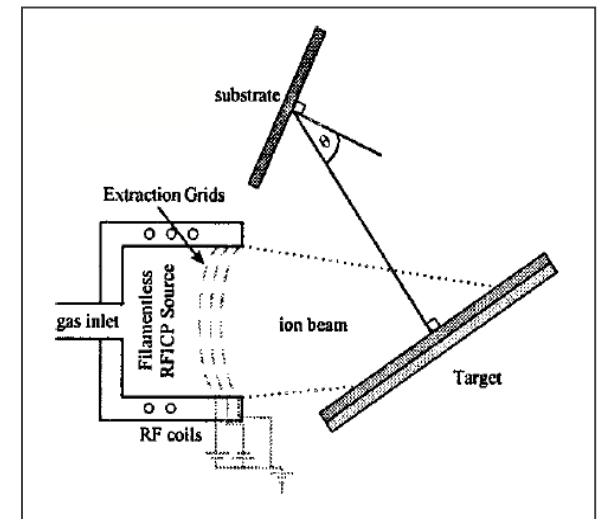
~ 40 bilayers
Mo3nm/Si4nm
(~7nm)

substrate

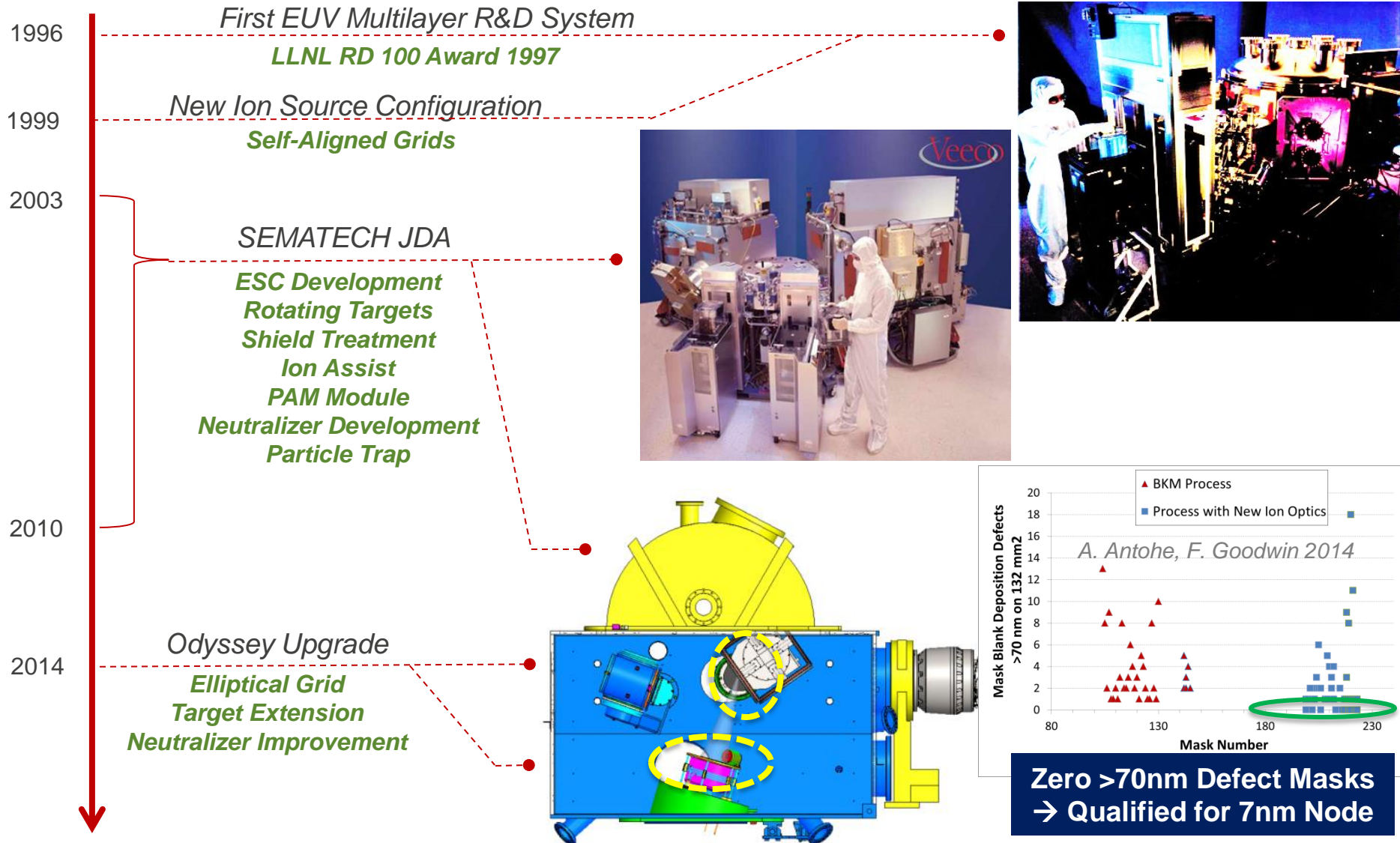


Ion Beam Deposition Advantages

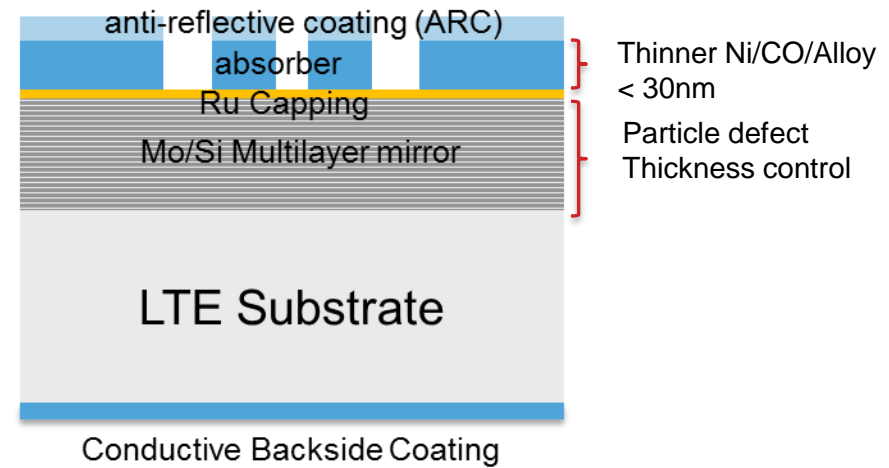
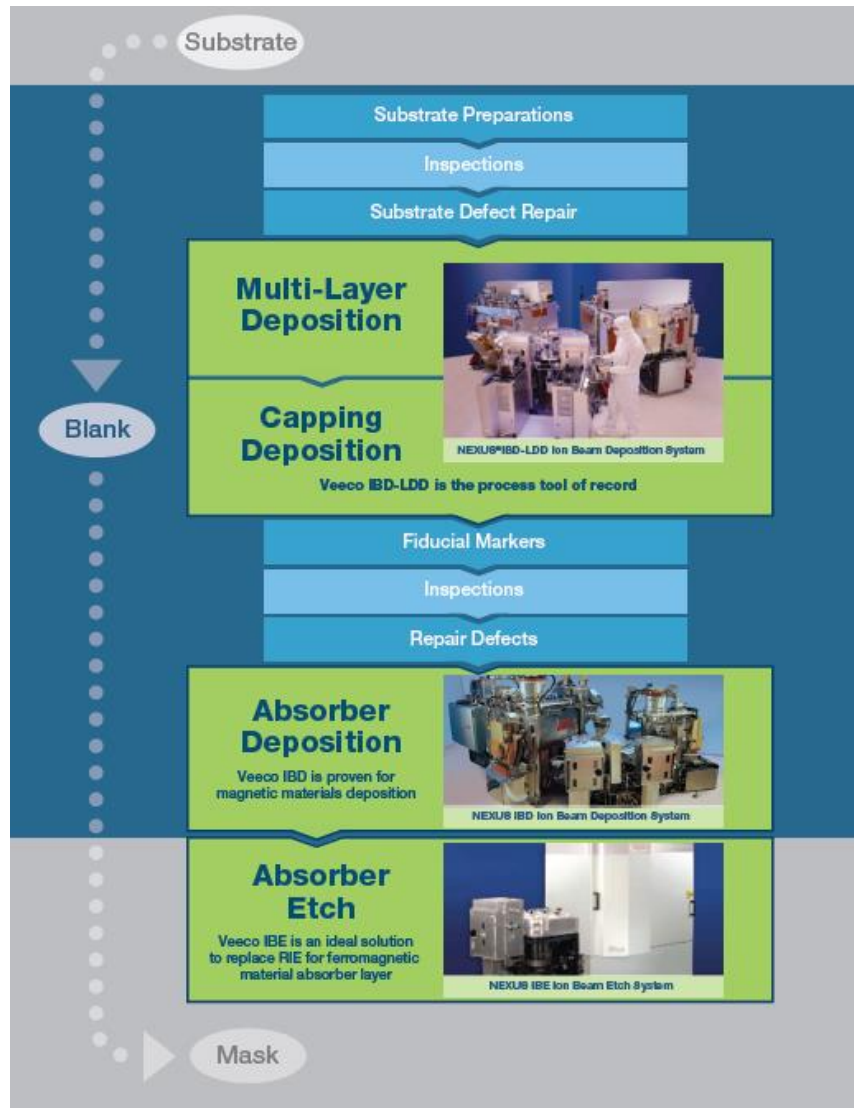
Defects	Plasma remote from substrate Electronic shutter => continuous plasma Controlled rate minimizes decoration	0 defects at >70nm
CWL Uniformity	Fixture tilt & rotate	~ 0.2% 3σ
Reflectivity	Controlled rate for layer smoothness & repetition	> 67%



Veeco History of EUV Mask Blank Deposition

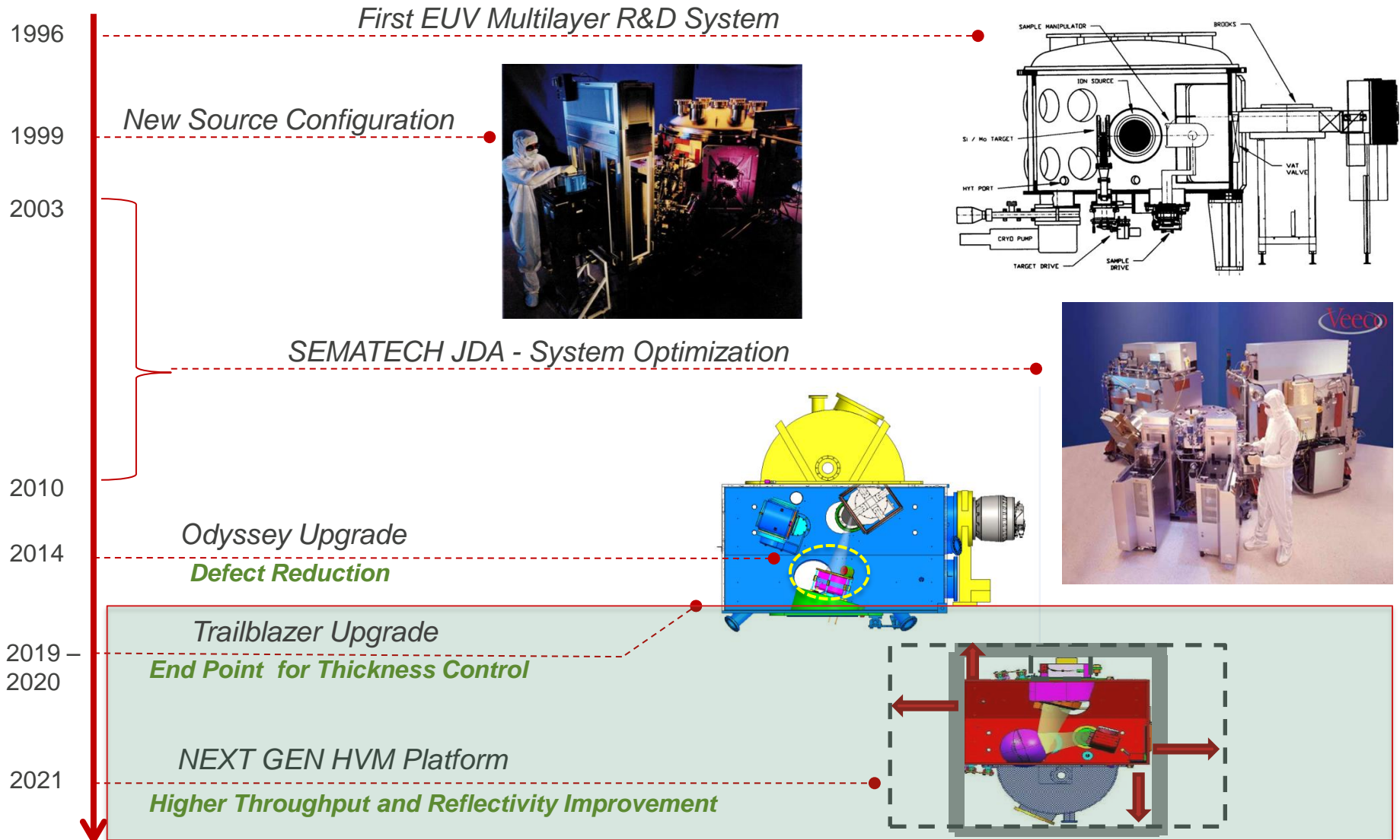


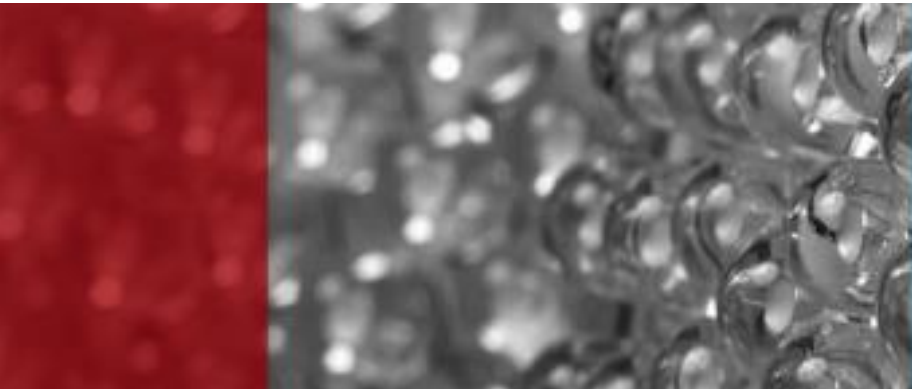
Broader Veeco Involvement in EUV Mask Blank Manufacturing



- > Multilayer/capping deposition – improvement required for 5nm technology node
- > Absorber deposition and etch – new material (Ni, Co, ..) required for future technology node

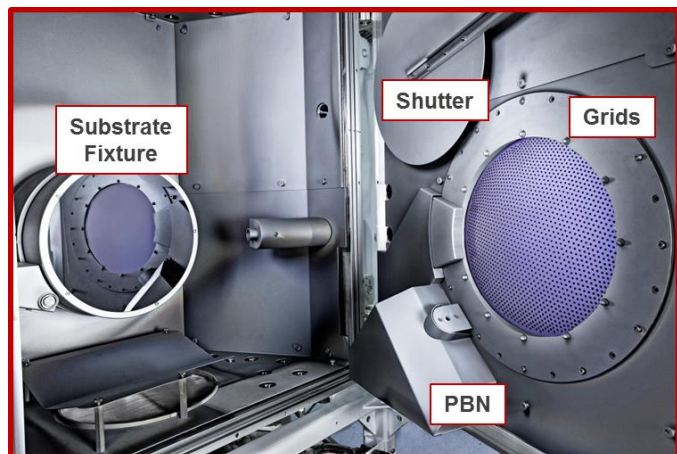
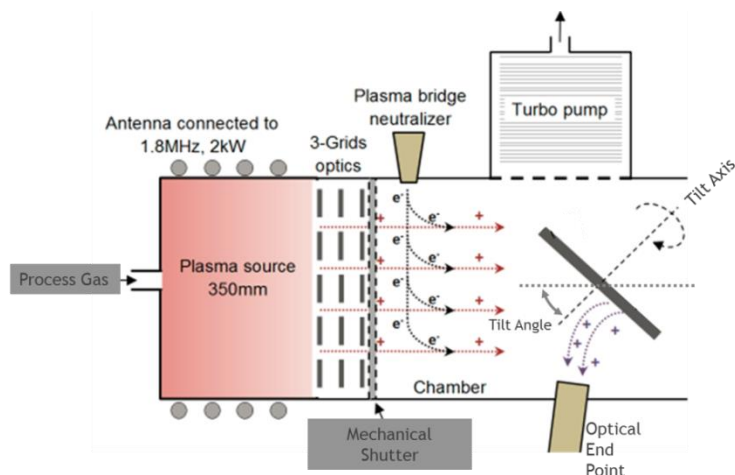
Roadmap for IBD-LDD Multilayer Deposition





Ion Beam Etch for Next Gen EUV Absorber Materials

Veeco Ion Beam Etch for Next Gen Absorber Layer

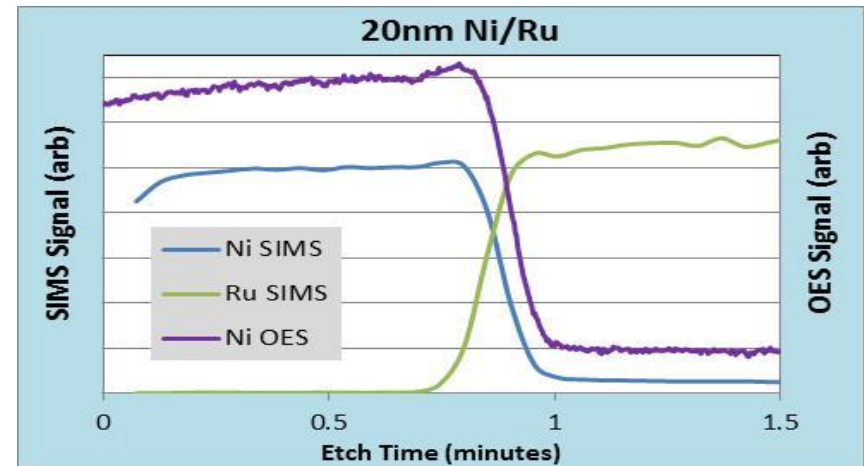
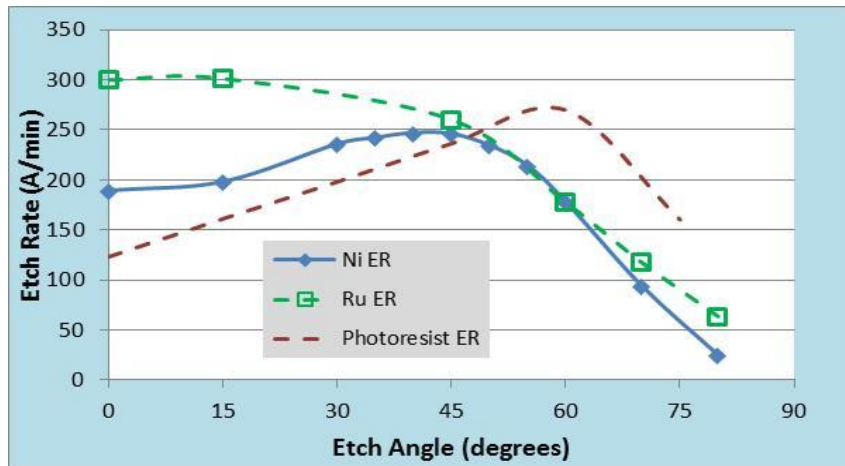


IBE Feature Selected Benefits

Physical etch	<ul style="list-style-type: none"> ✓ Any material - no chemistry dependence ✓ Complex materials and structures ✓ No chemical damage ✓ No chemical residues ✓ No chamber conditioning, memory effects ✓ Dense and isolated features etch at same rate
Directional ion beam	<ul style="list-style-type: none"> ✓ Anisotropic etch ✓ Device shape & sidewall angle control ✓ Eliminate re-deposition
Ion source isolated from substrate	<ul style="list-style-type: none"> ✓ Low pressure operation: low contamination & re-deposition ✓ Process flexibility: Independent beam and voltage control ✓ Low energy capability, down to 50V ✓ Low ion damage ✓ Low temperature operation

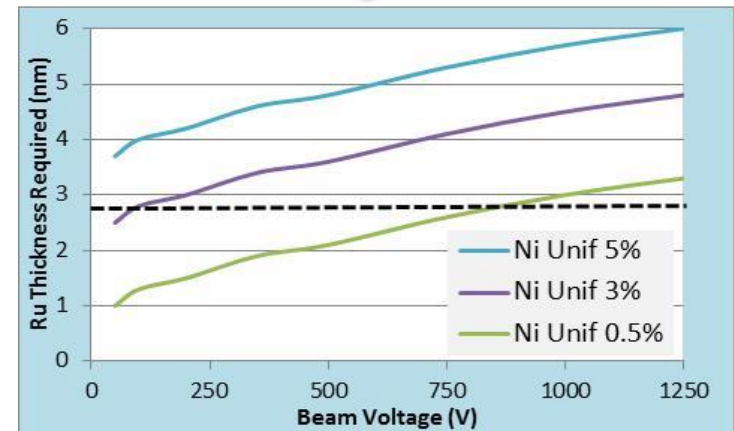
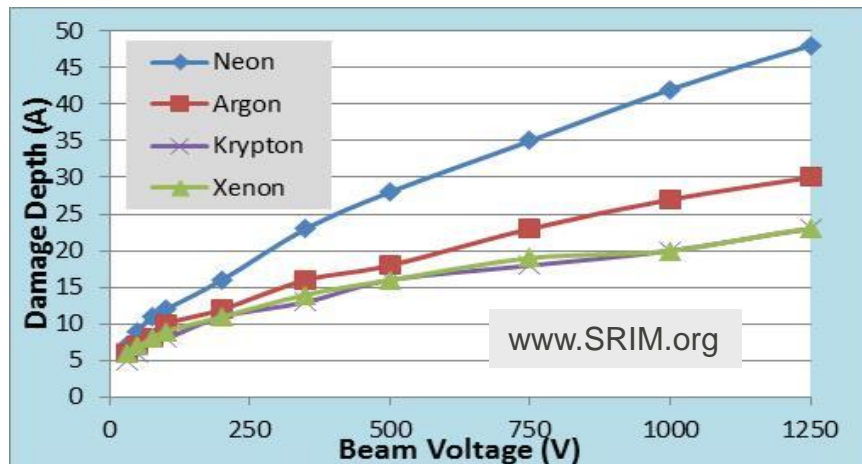
Industry standard for magnetic and novel material etch

Ion-Beam Etch & Endpoint for Patterning of Ni/Ru Absorber



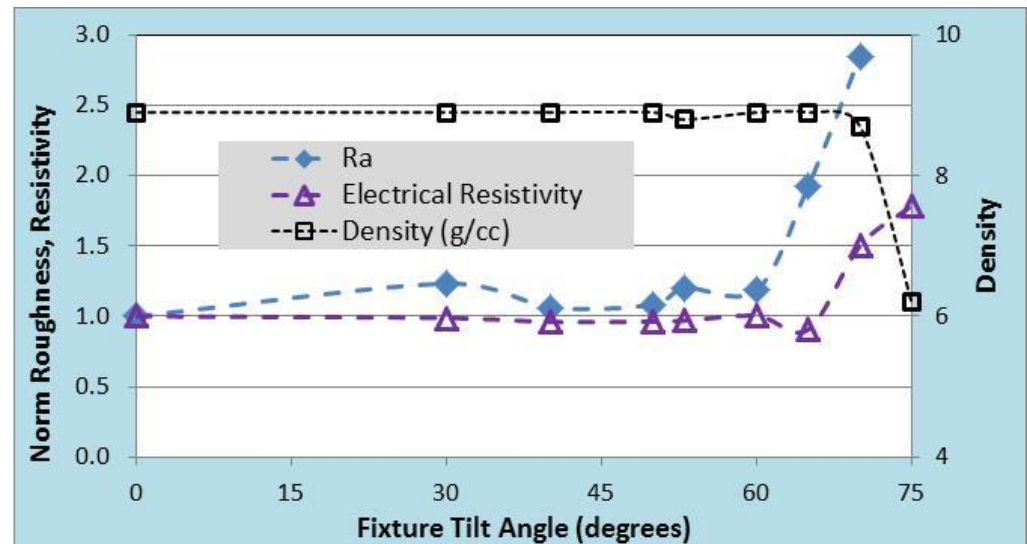
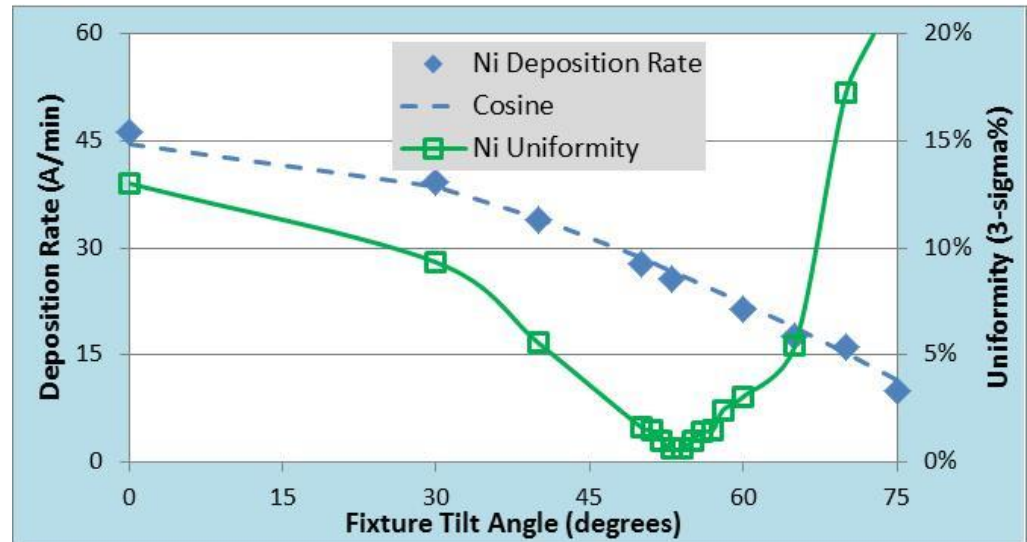
- ❖ Ni ER 200 ~ 1000Å/min
- ❖ Ni : Ru 0.7-1.5 => resist mask > 80nm

- ❖ Ni/Ru endpoint by OES or SIMS
- ❖ Ni : Ru < 1 : 1 => Ru Thickness



Ion-beam Deposition of Uniform Ni Absorber Layers

- ❖ Ni uniformity $\sim 0.6\%$ 3σ
- ❖ Deposition rate up to ~ 125 A/min
- ❖ Density and surface roughness not impacted at optimized angle



Summary

- > 20 years of involvement in EUV market
- > Veeco IBD-LDD is the tool-of-record for EUV mask blanks multilayer (ML) deposition
 - » Tool meet requirements for 7nm technology node
 - » Actively working to improve for future node
- > Ion beam etch is a viable option to pattern near future absorber materials
- > Ion beam deposition can be extended for highly uniform absorber layer